As I have already shown, it is generally at a late period in the treatment of a case that these organisms appear; generally where the dressings have been left on for several days; or where the discharge has reached the edge some hours before changing it; or, if they occur early, it is when the discharge which has come through has been considerable, although the dressing has been changed early; and thus I have been able in some cases to prevent the entrance of these organisms by changing the dressings daily, and, conversely, they are easily enough obtained in any given case simply by dressing it less frequently. This will be readily seen from the cases quoted before.

If such a fluid as milk be tested with the view of determining the amount of carbolic acid which must be added in order to prevent the development of organisms, it will be found that a large quantity is necessary. Thus, they readily develop in a proportion of carbolic acid and milk, 1–60, and I have grown them in as large a proportion as 1–54. On examining the milk while the carbolic acid is being added, a granular precipitate will be seen to take place. In the same way, if carbolic acid is added to serum or white of egg, a white precipitate occurs, and here also a large proportion of carbolic acid is necessary to prevent development. In artificial cultivating liquids—such as Pasteur's fluid—no precipitate takes place, and a much smaller quantity of carbolic acid is required to hinder the growth of organisms. In other words, where carbolic acid is added to an albuminous fluid, a compound is formed which is but little antiseptic. So in the case of the antiseptic dressings, where there is profuse discharge—though the first which comes through may not be putrescible, yet very soon the carbolic acid is not present in sufficient quantity to prevent the development of organisms; and, as carbolic acid is very volatile, when a dressing is left on for several days, a considerable amount of carbolic acid will have also escaped by evaporation, and thus the meaning of the following rules of treatment, derived from experience, becomes evident: 'A dressing must not be too small.' 'The dressing must not be left on longer than twenty-four hours after the discharge has appeared at the edge.' 'In no case is it safe to leave a dressing unchanged for more than eight days.'

Experience has shown that any marked disregard of these rules will, in all probability, be followed by putrefaction in the wound.

But this still leaves unexplained why it is that *micrococci* only are found in wounds treated aseptically. At first the only hypothesis which I could think of was that micrococci can grow in fluids containing carbolic acid in larger quantity than those in which bacteria can develop. I have accordingly performed numerous and elaborate experiments to test this view, but I have been quite unable to find any such difference in the first instance. An observation which I made in the course of these experiments seems, however, to furnish the clue to the mystery. I had previously observed that where one flask was inoculated with bacteria and another with micrococci in like amount, that which contained the bacteria was, as a rule, muddy in from twelve to twenty hours (the quantity of fluid in each flask being ʒiij to ʒiv), while thirty to fifty hours elapsed before the fluid in the flask into which the micrococci had been introduced became opaque. But if carbolic acid, say in the proportion of 1 to 500, be previously added to this fluid, the result is just the reverse: the flask containing the micrococci becomes opaque in twenty-four hours, while that containing the bacteria does not become muddy till a later period. Following out this line of investigation, I have found that if micrococci and bacteria be introduced together into a cultivating fluid containing carbolic acid, the micrococci will develop rapidly, often to the complete exclusion of the bacteria. Where no carbolic acid is present, the result is generally the reverse; most forms of bacteria grow quickly, the micrococci being often apparently prevented from developing. But, it may be said, in the former case the bacteria became converted into micrococci. But if the same bacteria be introduced into a flask containing no micrococci, bacteria alone develop.

So in the room in which I work, I have never been able, without the aid of the spray, to transfer micrococci from one flask to another. For in the latter flask *bacteria* almost invariably developed. But if carbolic acid be previously present in the fluid, the operation may be done in the most leisurely manner, with practically a certainty of obtaining micrococci alone or chiefly in the second flask.

It is thus apparent that though bacteria and micrococci can grow in fluids containing like amounts of carbolic acid, yet the micrococci find these liquids more suitable for their growth than do bacteria; indeed, they may grow more rapidly in them than in fluids containing no carbolic acid at all, and therefore, when bacteria and micrococci fall together into discharge containing carbolic acid, the latter develop with much greater rapidity than the former, and may thus reach the wound long before them. If, however, sufficient time be allowed to elapse before the changing of the dressing, bacteria also may enter the wound.

One other observation completes this subject. The largest proportion of carbolic acid in cucumber infusion in which organisms develop is from 1–450 to 1–500. In one of the last experiments performed with the view of seeing whether micrococci could grow in a larger proportion of carbolic acid than that sufficient to prevent the development of bacteria, I used micrococci which were growing in a fluid in which a small quantity of carbolic acid was already present. This was done on April 14th. On examining the flasks on April 15th, I found one containing carbolic acid in the proportion of 1–400 quite opaque from the development in it of micrococci, while those in which a larger proportion of carbolic acid was present remained clear. On the same day I inoculated from flask 1–400 a new series containing carbolic acid in the following proportions: C 1–400, C 1–350, C 1–300, C 1–250. On April 16th, C 1–350 and C 1–400 were quite muddy from the presence of micrococci; while C 1–300 and C 1–250 were clear. That afternoon, a fresh series, C′ 1–350, C′ 1–300, C′ 1–250, C′ 1–200, was inoculated from C 1–350. On April 17th, C′ 1–300 and C′ 1-350 were muddy. Here the limit seems to have been reached. For though I have obtained slight development in carbolic acid and cucumber 1–275 and 1–250, this is not vigorous. As the micrococci grow in larger proportions of carbolic acid, they become much larger, and the grouping and mode of growth described by Mr. Lister are more evident.

The facts then seem to be that the discharge, when profuse, or when it arrives at the edge of a dressing which has been left on for some days, does not contain sufficient carbolic acid to prevent the development of organisms in it; that micrococci, which I find to be *more abundant in the ward atmosphere* than bacteria, find this a particularly favourable medium for growth; and that as they grow they increase in vigour, and become more able to live in fluids containing a larger proportion of carbolic acid, and thus, if time be given them, they will eventually reach the wound.

Since these investigations were made, I have been able to *demonstrate* the spread inwards of organisms under a gauze dressing. Look for a moment at Case 12, p. 241. A specimen of the discharge was taken on March 31st, from the gauze dressing near the edge, and was found to contain *micrococci and bacteria*. No organisms had, however, as yet reached the wound (see Fig. 18, Plate III.). This dressing was removed, a new dressing applied, and the organisms had to begin again at the edge. Fig. 19, taken from the dressing near its edge, and Fig. 20, taken from the drainage tube four days later, illustrate the same thing. Here also the organisms were penetrating inwards under the dressing, but had not yet reached the wound, and it was not till two days later that the first traces of micrococci appeared in the wound.

The same thing is demonstrated in Case 13, p. 242. Here Fig. 21, Plate III. is a specimen taken from the gauze near the wound, and it contains *a few micrococci*: they had not, however, reached the wound, and did not do so till some days later.

Then, again, I have been able to keep out these organisms simply by dressing more frequently so as to anticipate them before they reach the wound, as may be seen in the case of empyema, &c. And Dr. Ogston does not find micrococci in his aseptic cases, because he dresses much more frequently than Mr. Lister, never allowing the discharge to appear at the edge of the dressing at all.

It will not, however, be always necessary that the discharge should appear at the edge, for if a dressing be left on for several days sweat accumulates under it, and will serve the same purpose as the serous discharge in conducting organisms inwards.

At the same time it is possible that organisms may occasionally enter the wound from the blood, especially in the conditions of interference with the healthy state which were formerly alluded to; and it is also possible that they may enter from fault in the aseptic precautions, though I think this must be exceedingly rare. For it is difficult to imagine that in the latter case only micrococci would get in; indeed, in faulty experiments with cultivating fluids, it is almost invariably some form of rod-shaped organism which appears.

CHAPTER XIII.

ANTISEPTIC SURGERY.

Complete definition of antiseptic surgery. Varieties of antiseptic surgery. TREATMENT BY ANTISEPTICS: Carbolic acid—objections to it: Chloride of zinc: Boracic acid: Sulphurous acid: Chlorinated Soda: Alcohol—Hutchinson's method: Terebene and Sanitas—Bilguer's method—Neudörfer's salicylic powder. FREE DRAINAGE AS AN ANTISEPTIC METHOD. IRRIGATION AND IMMERSION. OPEN METHOD: Modes in which it acts antiseptically: Bartscher and Vezin's method: Burow's method: Rose's modification. HEALING BY SCABBING: Methods of forming a crust: Bouisson's ventilation method: other modes. GUÉRIN'S COTTON-WOOL DRESSING. MODES IN WHICH THE DESTRUCTIVE ACTION OF THE TISSUES ON BACTERIA IS ASSISTED. Why does not fermentation always occur in the blood in wounds in which organisms are present? Best practical methods. Conclusions.

WE have now arrived at the end of our discussion as to what are the particles which cause putrefaction; what are the exact enemies with which we have to contend in attempting to prevent putrefaction. We have seen that it is from particles falling into fluids or on tissues that organisms develop. We have seen that it is only after the access of particles from the outer world to such fluids and tissues that fermentations occur, and we have satisfactorily demonstrated that the particles which cause fermentations and those which give rise to organisms, are one and the same—in other words, fermentations are due to the growth of organisms in fluids or tissues. We have also seen that these same laws, with one exception, to be presently mentioned, hold good when the fluids or tissues are confined in the living body, just as when they are in flasks, viz., that the particles which cause putrefaction and other fermentations only rarely enter such substances through the circulation, but generally reach them directly from the air or from surrounding objects; that so long as an animal is healthy, dead